

From a load-capacity point of view, the most suitable gearhead ratio has the highest torque density for the most compact (and cost-effective) package. From an application point of view, the best gearhead ratio for a dynamic automation application is based on two things: The torque required to accelerate the load, and the required inertia match. The former is important because the gearbox must boost motor torque to a sufficient level. The *inertia-match* — the load inertia reflected to the motor axis divided by motor rotor inertia — equals load inertia divided by the gearbox reduction ratio squared. So, having an appropriate gear reduction between the motor and load can drastically reduce load inertia as referenced from (or experienced by) the motor. Selecting the right ratio actually allows dynamic tuning of the servo system.

*This month's handy tips provided by Gerhard Antony, Ph.D. of Neugart USA LP, in Bethel Park, Pa. For more information, call (412) 835-4154 or e-mail the editor at [eeitel@penton.com](mailto:eeitel@penton.com).*

## Q&A

### **What affects a gearset's load rating?**

The ratio of a gearhead has significant impact on load capacity. For example, say one gearset has a ratio of 3:1. The planets will be small compared to the sun gear. On the other hand, a set with a 10:1 ratio has relatively oversized planets — and therefore, load-carrying capacity is most limited by the sun.

The best balance of gear geometry is somewhere in between these extremes. As a general rule of thumb, the sweet spot of ratios for maximized torque capacity is somewhere between 4:1 and 6:1.

### **How can load rating be increased?**

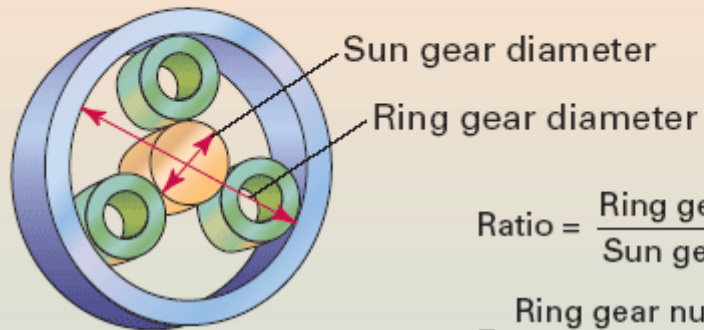
The torque carrying capability of a planetary gear (also called *torque density*) can be increased by adding additional planet gears. That said, there is a limit to how many can be added. For example, the maximum number of planet gears in a system with a 10:1 ratio is 3.

### **What is one common pitfall?**

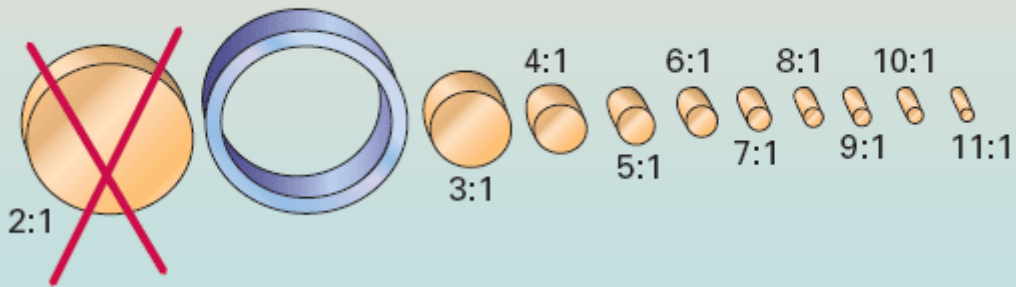
Often, designers specify gearsets with a 10:1 ratio because the mental math is logical and simplified. However, such a ratio isn't better for digital controllers; computers have no "preference" as to what numbers they're required to multiply or divide. In fact, as mentioned, a 10:1 planetary ratio has not only the strongest torque limitations due to its tiny sun gear, but torque capacity cannot be boosted by adding planets, because there is simply not enough space for a fourth planet gear.

In short: If a motion system doesn't absolutely mandate a 10:1 ratio, then it's best avoided.

## Calculating the ratio



$$\text{Ratio} = \frac{\text{Ring gear diameter}}{\text{Sun gear diameter}} + 1$$
$$= \frac{\text{Ring gear number of teeth}}{\text{Sun gear number of teeth}} + 1$$



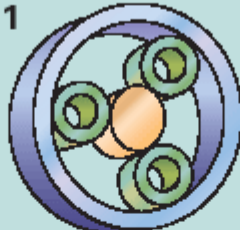
## Better balance

3:1



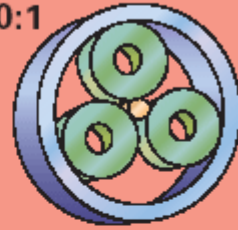
Torque limited  
by planets...

4:1

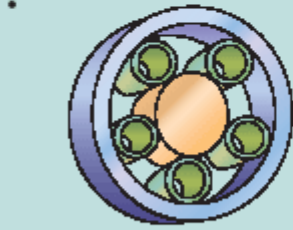


Planets and sun  
of equal size...

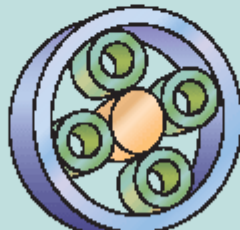
10:1



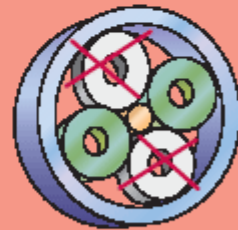
Poorly balanced  
geometry...



More planets  
increase load ability.



Additional  
planets possible.



More planets  
not possible.

**Thin-walled and small-diameter gears limit load capacity.**

Motion System Design | Copyright © 2006 Penton Media, Inc. All Rights Reserved.

